# “TELEMETRY COMMUNICATIONS PRESENT AND FUTURE”

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## ABSTRACT

This paper covers communications between Telemetry outstations such as pump stations, treatment plants and reservoirs, and a master station. The primary focus of the paper is wireless trends, with a mention of other non-wireless technologies and background material to provide a framework of understanding. I also outline the special requirements of this type of communications network; capital costs, running costs and technical aspects.

The paper is divided into four sections:

The first covers the requirements of RTU communications system, both practical and technical, with issues of network ownership and control.

The second section discusses the existing technologies used for communication, forming a basis for understanding the implication of emerging technologies which are addressed in the next section.

The third section covers the advantages of using some of new communications technologies that have emerged in the past ten years and difficulties encountered.

The final section presents the author's vision of the way Telemetry and SCADA systems will use communications in the next ten to twenty years; what technologies will be popular, what standards will be in use and how to plan now for the future.

## KEYWORDS

**Bandwidth, baud rate, polling, protocols, RTU, SCADA, TCP/IP, telemetry, wireless**

# 1 INTRODUCTION

Communications is the heart of telemetry. The future of communications profoundly affects the future of telemetry systems and their applications in water and wastewater reticulation systems.

## 1.1 WHAT IS THE JOB OF TELEMETRY

Telemetry means measuring at a distance. In the instance of water and wastewater reticulation telemetry systems, it makes information about far-flung plant such as reservoirs, treatment plants and pumps available at a central point. In order to accomplish this task it needs a communications system to pass information from the remote plant to the central site.

Understanding the job of telemetry affects the requirements of the communications system.

### 1.1.1 ALARMS

Alarms are the most immediate and generally the most important function of a telemetry system. Alarms, such as reservoir low, pump fail and well flooding must be communicated reliably and quickly to those who can rectify the situation.

If the system cannot perform the alarm function reliably it will lose credibility and its other uses will not be trusted.

### 1.1.2 INFORMATION

Collection of information such as reservoir level, pump state and equipment hours is a less important function of telemetry systems. Typically this information is used to program and target maintenance, make control decisions, gather information for future planning and display current system status.

### 1.1.3 CONTROLS

Controls may be issued by either the central station or other sites in response to information gathered by the telemetry system. A simple example of this is a control to turn a pump on when the associated reservoir is low. Complex control scenarios such as balancing flows to a treatment plant or regulating valves to maintain a pressure, are often required and are influential in determining communications network capability.

## 1.2 COMMUNICATIONS - DEFINITIONS

In order to provide a framework for understanding the future of communications some background material is presented here.

### 1.2.1 BEARER

The communications bearer is the medium over which communications travels. Bearers can be divided into two very broad categories: landline and wireless. Within each of these categories there are distinct variations; for example, wireless can be divided into switched or shared circuits (cell phones, trunked radio), and private. Each of these can be stratified as to modulation frequencies, modulation technique (AM, FM, spread spectrum) and transmitting power. Similarly, landline can be stratified into shared (PSTN) and private (2 / 4 wire circuits, optical fibre).

### 1.2.2 BANDWIDTH

Bandwidth can roughly be translated into how much information can be transferred within a set period of time. In general, the trend is to provide more and more bandwidth to communications systems. Coverage of difficult sites is affected by bandwidth; generally the higher the bandwidth the more difficulty with coverage. Bandwidth for its own sake is not necessarily desirable. There are numerous cases where it is not so and this will be addressed further on.

### 1.2.3 PROTOCOL

A protocol is an agreed set of rules to allow devices to communicate with one another. Typically they will have error detection techniques and addressing so that messages go to the correct place. There are several important things to note about protocols. The big issue these days is whether the protocol is Open or Proprietary. An open protocol is a published protocol to which a number of manufacturers adhere, theoretically making it possible for devices from these manufacturers to communicate with one another. A proprietary protocol is one of a manufacturer's own design, often to allow special features not supported by the various open protocols.

Protocols have different layers, one to define the techniques by which the message is sent and received, another to define the content of the messages. It is entirely possible for two devices to have the same protocol and be unable to communicate with each other because one of the layers is differently defined.

An example of a Transport level protocol is TCP - Transmission Control Protocol, the protocol of the internet. TCP doesn't define the message content, so two TCP devices may communicate with each other but not understand the data. An example is a telephone call from Wellington to Beijing. I can talk with the person in Beijing but since I'm conversing with someone who doesn't speak English and I don't speak Mandarin, we don't communicate.

Modbus is an Application level protocol and contains all the layers beneath it (such as transportation). This means that everything is defined in the set of rules for this protocol. A Modbus sender will always be understood by a Modbus receiver.

## 1.3 FUTURE TRENDS

In general, the use of communications networks, (wireless in particular) is burgeoning and this is a trend expected to continue in the future. Communications for telemetry purposes is expected to follow the mainstream trends and make use of the more advanced networks and equipment that will inevitably become available over the next ten years.

The major feature will be the conflict between bandwidth and coverage. Most modern systems opt for increased bandwidth at the expense of coverage.

# 2 COMMUNICATIONS SYSTEM REQUIREMENTS

## 2.1 COVERAGE

The primary aim of the communications system is to be able to communicate with all of the sites that require telemetry. The characteristics of the communications can be dictated by the needs of those sites that are most difficult to communicate with. In order to operate effectively the telemetry system should cater for the weakest link and not impose communications requirements that these poor coverage areas cannot cope with.

Coverage is the "big issue" of any telemetry communications system. The need for complete coverage excludes the use of many advanced and high speed communications technologies as the only solution.

### 2.1.1 SITE LOCATION

Water and wastewater systems sites are determined by hydraulic and infrastructure factors. Reservoirs are located on heights and are generally good sites for wireless communication. However, they are also often located on remote hilltops and it is expensive to run cable to these sites. Pump stations – especially sewage pump stations - are often located in low lying areas which are difficult for wireless communications but often close to cable infrastrucure. Sewage pump station location provides the biggest problem for wireless communications because – of necessity – they are often located in topographic low points not conducive to good radio coverage.

Photograph 1: Sewage Pump Antenna System

### 2.1.2 RULES OF THUMB

With wireless systems there are several basic rules that govern ease of coverage:

1. Height is good; this applies to site location and in particular the antennas;

2. The lower the modulating frequency the more noise – but the coverage is generally better as the signal reflects better; Friis law of transmission;

3. The higher the transmission speed the more susceptible to noise it is;

4. The weakest link in a telemetry system is the comms system.

## 2.2 OWNERSHIP OF COMMUNICATIONS

The ownership of the communications network can be an important consideration. Financially it makes sense to use communications providers such as Telecom and Vodafone as opposed to incurring the capital costs for owning one's own communications network. Running costs then become an issue, with the costs of using a provider as opposed to the cost of maintaining a private network.

## 2.3 RELIABILITY

The communications system is at the heart of any telemetry system. As important alarms and controls are transmitted via the communications systems, it has to be extremely reliable. There are several general techniques for achieving the high degree of reliability required by these systems.

### 2.3.1 SIMPLICITY

Simple systems have fewer things to go wrong. When they do occur, problems are easier to diagnose and repair. Having said this, simplicity is often difficult to achieve. Imposing simplicity on an inherently complex application such as a communications system is decidedly NOT simple. However it is often worth the effort.

An example is a system that we installed a number of years ago. A linked repeater system seemed the obvious choice for coverage but we persisted and found a solution that used less equipment, fewer frequencies and ultimately caused less trouble. The solution used one repeater site which got 80% of the sites, and by raising the antenna at the base station we were able to directly contact the remaining 20%.

Licenced frequency systems in the UHF/VHF bands present the simplest solution.

### 2.3.2 REDUNDANCY

Another way to achieve reliability is by having duplicates of system items that give the most trouble or duplicates in choke points. Hot standby repeaters and base station transmitters are common. There are often path problems such as radio interference which can bring a system down. The ability to change channels or transmit via different repeaters can significantly improve reliability.

Some systems duplicate the path using very different bearers: if the radio channel is unavailable – for whatever reason – it will attempt to use the telephone network. The likelihood of both comms systems not working at the same time is small.

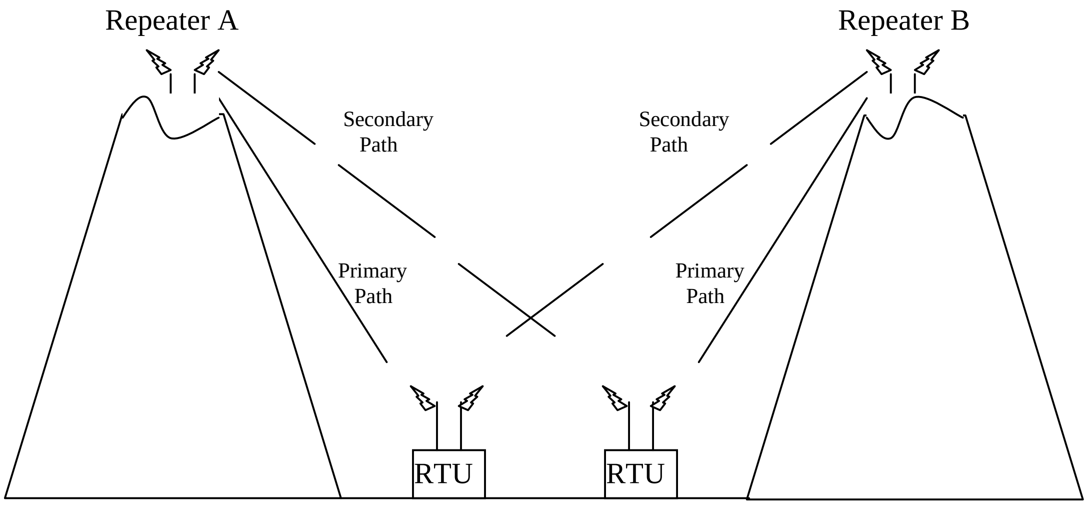



Figure 1: Repeater and comms path redundancy

Some protocols – notably TCP – can adapt the route by which they communicate to meet changing circumstances. This multi-path ability makes TCP a very robust and successful protocol.

### 2.3.3 CHOICE OF EQUIPMENT

For reliable communications the cheapest equipment is rarely the best choice. My experience is that communications systems work best when well-proven, rugged and reliable equipment is used. “Features” rarely enhance reliability.

### 2.3.4 CHOICE OF SERVICE

If a communications service provider such as Telecom or Vodafone is chosen, its attitude towards reliability is important. Some companies’ focus is on the consumer market and is therefore price driven. Again, proven companies with a broad focus are the best bet.

## 2.4 AVAILABILITY DURING EMERGENCIES

A key feature of a telemetry communications system is that it must be available during emergencies such as earthquakes, major fires, volcanic eruption etc. Basic public utilities and knowledge of their availability and operability is vital at these times e.g. is there enough water in the reservoir to fight the fires?

### 2.4.1 OWNERSHIP OF SYSTEM

A privately owned system has the advantage over a communications service provider in times of emergency. The concern with a shared network such as cellular, is that the infrastructure may well be swamped with calls, blocking essential data from reservoirs and pump stations. With a private network (and make sure that it is *really* private) the communications traffic can be controlled by the utility that owns it.

### 2.4.2 SECURITY OF INFRASTRUCTURE

Sites such as radio repeaters, cell towers and telephone exchanges must be secure and operational after a major civil emergency. Most service providers have adequate precautions in terms of equipment reliability and site protection (auxiliary power supplies, secure mounting of equipment and antennas etc) but often their sites are not ideally located. If the water utility owns its own communications network it can ensure the infrastructure’s security.

## 2.5 BANDWIDTH

### 2.5.1 THE BIG SECRET

What is not widely appreciated is the fact that in a telemetry system for reservoirs and pump stations there is not very much information that needs to be sent. For example, a sewage pump may start 40 times a day, be switched to manual once every month and have perhaps one alarm condition a year. As stated above, the user will need to know the alarms, whether the pump needs maintenance, and in rare situations whether the pump is operating or not. In order to achieve the above objectives, pump alarms, number of starts, pump current, equipment hours and pump state need to be transmitted. This comes to 1200 bytes of information per day.

The reasons for operating communications networks with capabilities many orders of magnitude more capable than 1200 bytes per day are varied. The most typical is that people are trying to replicate a factory situation where all devices are on a local high speed circuit. The SCADA Master timestamps data as it is received and a high speed polling regime is required for accuracy of items such as equipment hours, pumping rates etc.

### 2.5.2 MESSAGE INITIATION TIME

This is the time that it takes to get a connection to the RTU (or for the RTU to connect to the Master). In a radio system it means the time from initiating the message (generally by activating the transmitter which then has to key up a repeater) to the time that it is ready for data to be transmitted. In a PSTN type system this would be the time it takes to dial the Master's number and the Master's modem to pick up the phone. *In telemetry systems these times can be much longer then the time it takes to transmit the actual data*. For example the initiation time for a radio system with repeater is typically 0.5 second and the length of data transmission at 1200 bps is 0.1 second. The total message time is 0.6 second. If the data rate is sped up to 9600 bps the initiation time will remain the same (or increase in some systems as the carrier takes longer to stabilize) but the length of data transmission drops to 0.012 second, giving a total message time of 5.12 seconds. So an eightfold increase in data rate results in a 1.17 x increase in message speed. The equation worsens if the higher data rate results in more communications errors resulting in retransmissions. One retransmit every nine messages for 9600 bps will make the message rate equal to 1200 bps. Often it is much worse and 1200 bps is in fact much faster!

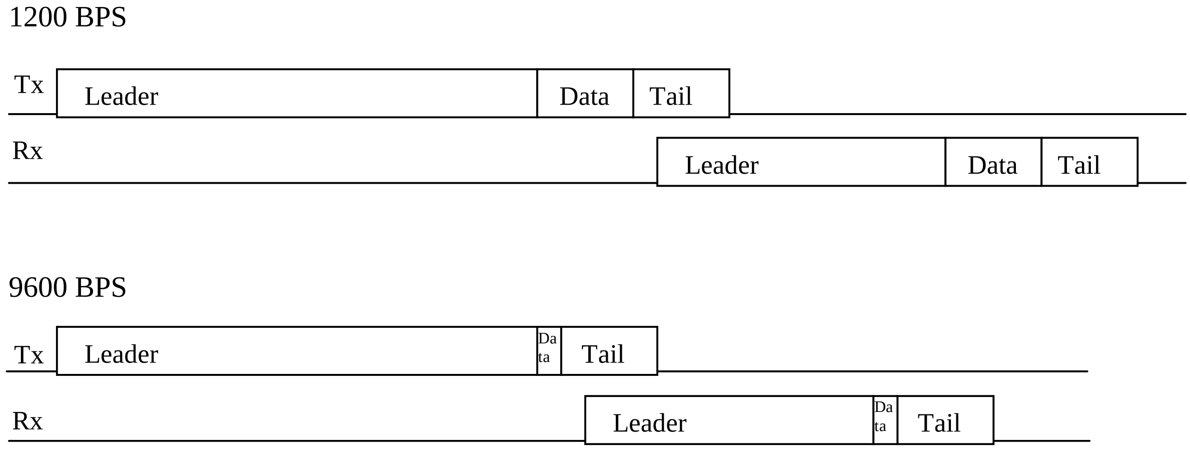



Figure 2: Message timings, showing relative times spent on sending data compared to message overhead

### 2.5.3 UPDATE TIME

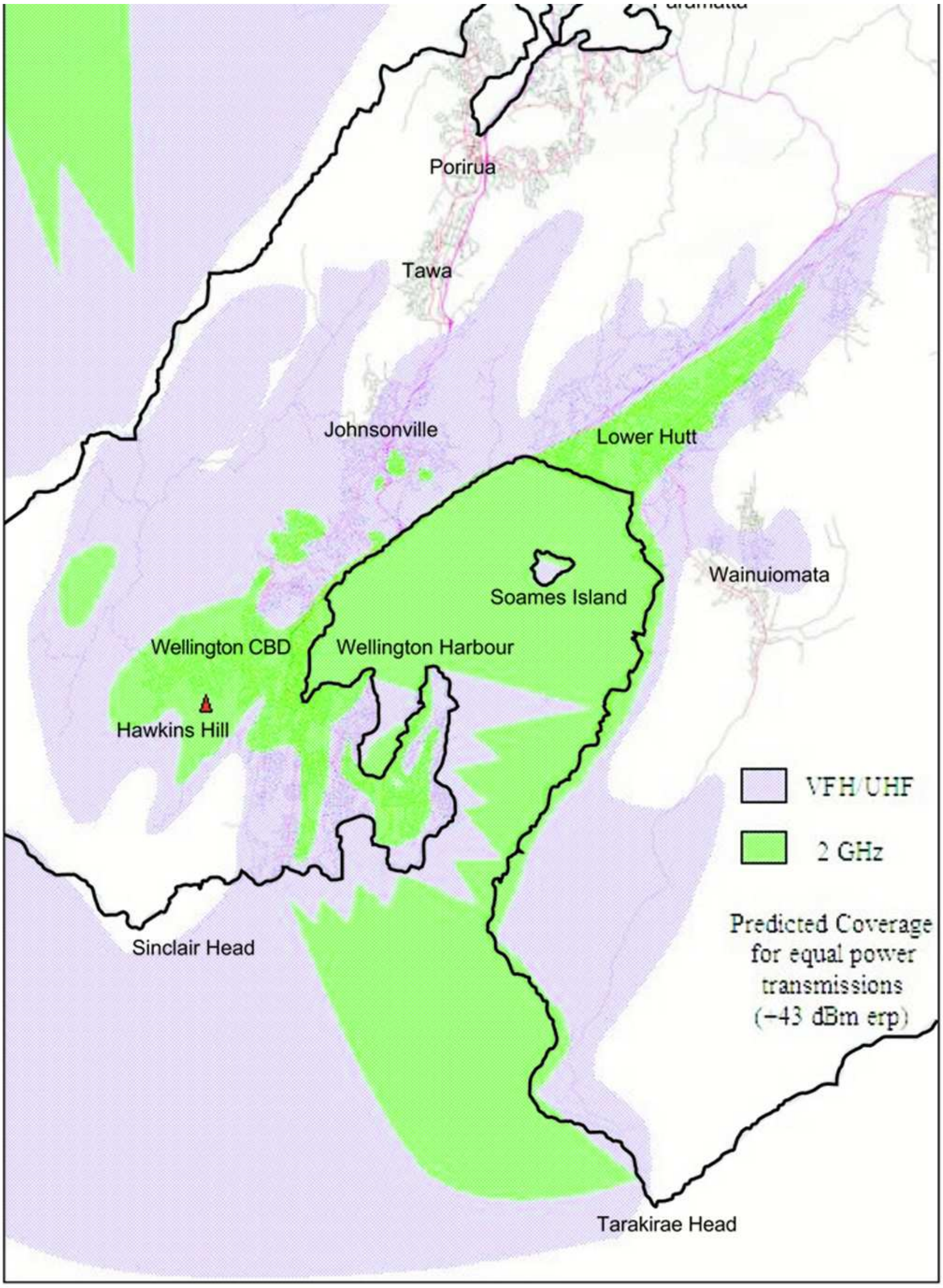
Update time is a function of message time and the frequency at which a Master requests updates. If the Master polls for information every hour then the information displayed at the Master can be at least an hour old.

There are good technical reasons for slow update times – a typical one is to reduce energy usage at solar powered sites such as remote reservoirs.

### 2.5.4 BANDWIDTH VS COVERAGE

As a rule of thumb, the higher the bandwidth the higher the frequency and the less noise tolerant the circuit is. Higher frequencies require line of sight between the transmitter and receiver – the higher the frequency the less tolerance of any obstruction. Also, high frequency transmitters tend to be lower in power and can't transmit as far.

Higher bandwidth channels are also more susceptible to electrical noise. This is a problem when the antenna is located near powerful and noisy motors as can be found in pump stations.



# 3 TECHNOLOGIES USED FOR COMMUNICATIONS

## 3.1 WIRELESS

Wireless communication uses high frequency (100 MHz – 5 GHz) carrier waves to transmit information from one site to another. Typically, as technologies advance the frequencies of the carrier waves increase. There are two main reasons – one is the lower frequency spectrum becomes fully occupied, and secondly the higher the carrier frequency the more bandwidth is available. To offset this advantage however, higher carrier frequencies do not provide the coverage that lower frequencies do and the transmitters typically have much lower power.

### 3.1.1 RADIO

Radio is the basis for all wireless communication. In this context however, we are talking about its simplest incarnation where it uses a pair of carrier frequencies (one for transmitting and one for receiving). At present this is the most prevalent method of communication between RTUs and the Master station.

Radio systems extend their coverage by the use of radio repeaters located on hilltops and other high places. The Master station transmits to the repeater which immediately re-transmits the message on another frequency to all and sundry able to receive the signal.

Radio systems typically operate in one of three frequency bands – VHF (100-200 MHz), UHF (400-500 MHz) and MAS (also UHF 850-930 MHz). As a general rule VHF provides the best coverage but has the noisiest signal.

### 3.1.2 SPREAD SPECTRUM

Spread spectrum is a radio technology whereby numerous carrier frequencies are used. The sending radio jumps from frequency to frequency in a preordained pattern. This frequency hopping allows other users of spread spectrum to transmit at the same time using a different pattern of frequency hopping.

Spread spectrum radios typically use frequencies raging from 850 MHz – 2.5 GHz. They are unlicensed in that any spread spectrum radio owner can operate at any location in the same band. The transmitting power of each set is limited to 1 watt. The more users, the more performance degrades. Because the 850-950 MHz spectrum is full in populated areas many users are migrating to the 2.5 GHz band.

Spread spectrum supports very high data rates but needs line of sight between antennas, and distances of 5 to 10 km.

### 3.1.3 DATA OVER CELLULAR

Cell phones are capable of carrying data just as the home telephone is. There are now special services offered by Telecom and Vodafone specifically for this function. The more primitive technique is to use a phone dialing sequence to establish a connection, the more modern approach is to use IP or Internet Protocol addresses.

### 3.1.4 SATELLITE

Satellite communications provides excellent coverage and is quite reliable but it is also very expensive. This technology has been available for the past 15 years but there has been no downward movement in price. The antennas are expensive and difficult to mount.

### 3.1.5 WIRELESS LAN – WIRELESS IP

A wireless Local Area Network (LAN) is a high bandwidth radio connection linking all sites and a Master unit. A LAN is unique in that it is a decentralized network - the Master can be located at any network node.

There is a lot of equipment coming on the market at the moment designed for wireless LAN applications.

### 3.1.6 MIXED NETWORKS – WIRELESS IP

One of our clients has the following setup: the basis is an Ethernet radio system consisting of a high speed/high cost 2 GHz backbone from microwave towers. There are local branches using lower data rate spread spectrum radios. The spread spectrum radios are much less expensive and are not as sensitive as microwave to coverage issues such as foliage, building obstructions etc. The radios used are MDS Inet, which are Ethernet spread spectrum radios in the 900 mHz. Band. The radios have 10baseT connector, as well as a serial gateway with dual RS232 ports. The data rate ranges between 1200-115kb per second.

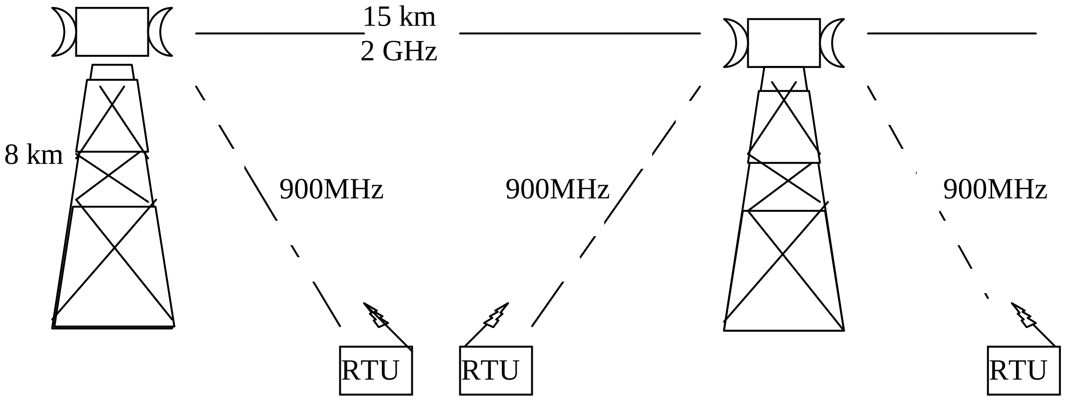



Figure 3: LAN Backbone system

In Los Angeles where radio spectrum is at a premium, the following setup works very well. They use 1 watt Ethernet spread spectrum radios which operate at 2.4 GHz. The longest hop is 20 km. The data rate is 1 MB - 11 MB. It uses Ethernet protocol with 128 bit encryption. 2.4 GHz RTs require careful setup and a strong knowledge of IT principles. This system can use redundant paths because the radios come with internal routing Linking into the SCADA package is relatively inexpensive.

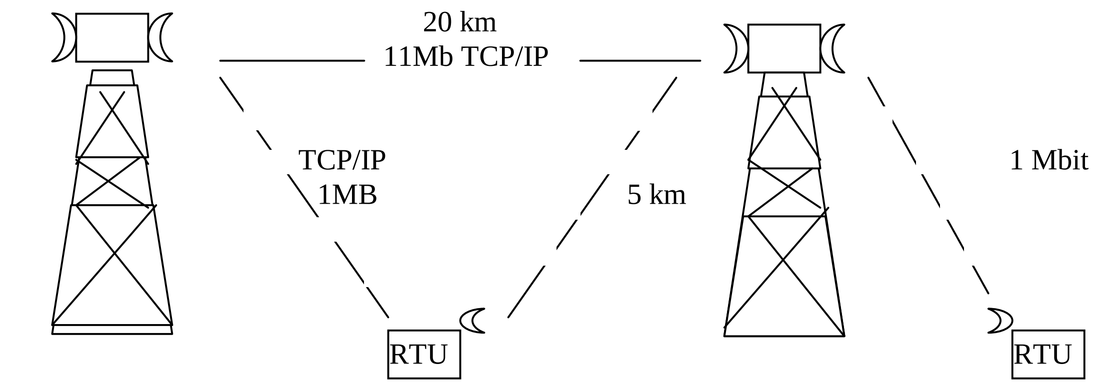



Figure 4: Wireless LAN

## 3.2 NON WIRELESS COMS PATHS

In this case landline means any cabling system to a site which enables communications. Two main categories exist – copper (conducting) wire and optical fibre. Although their communications characteristics are very different they both need trenching, stringing, connecting and other tasks associated with cabling.

### 3.2.1 2 OR 4 WIRE COPPER CIRCUITS

This is the oldest method of communicating with pump stations and reservoirs. Circuits were either rented from Telecom or installed by the water utility when laying pipes. The Telecom circuits have priced themselves out of contention and many of the water utility cables are nearing the end of their useful lives.

### 3.2.2 PSTN

PSTN means Public Subscriber Telephone Network - in short, the telephone. This uses landlines (2 wire circuits) connected to the nearest telephone exchange. Polling is done as a telephone call would be made – dial the RTU's telephone number, send the poll message, await the response and hang up. Therefore each poll takes 25-30 seconds rather than 2-4 seconds as per landline or radio.

The user is up for normal Telecom line rental charges and well as calling charges. PSTN is losing popularity as radio becomes easier. It is used mostly where radio communications is impossible.

## 3.3 FIBRE

Optical fibre is a relatively new technology which is replacing copper (electricity conducting) circuits for communications purposes. At the moment it is expensive but it has the advantage of extremely high bandwidth and high reliability. The infrastructure for fibre networks is not yet fully developed.

# 4 NEW TECHNOLOGIES FOR COMMUNICATIONS

## 4.1 WIRELESS COMMUNICATION

Wireless communication relies on a carrier frequency (or frequencies) to transmit the signal on. There are several trends with wireless communication – they are driven to increase bandwidth and find available space in the electromagnetic spectrum.

## 4.2 WIRELESS LAN

The Wireless LAN is a result of two technologies which will intersect when used for telemetry. The first technology is one being developed for office buildings – low powered but high data rate radio modems which allow the office LAN to propagate throughout the building and allow PCs to connect without the need for expensive wiring. This concept has been taken out of the office and using a number of low powered repeaters a wireless LAN can be created outside the office.

Then there are Wide Area Network (WAN) technologies using high powered spread spectrum radios. These systems are more robust and give better coverage but the bandwidth is much lower. In section 3.1.5 we mentioned an example of one currently being trialled by one of our US clients. They have a 2 GB Microwave backbone running through microwave towers in their area. Each of these towers has a 64 KB spread spectrum radio breakout which connects to the devices within range of the tower it is installed on.

The upshot of this is that there will be a multitude of products available which will make the establishment of LAN and WAN networks relatively easy.

### 4.2.1 ADVANTAGES AND DISADVANTAGES OF LAN COMMUNICATIONS

LAN communications is the direction in which communications is heading, be it wireless or cabled (landline). There are some major advantages for telemetry systems in this. The most important is the fact that messages between the RTU and Master can be transmitted by a number of different paths. If one path is inaccessible the LAN protocol (TCP/IP) will try another route.

Because of the popularity of LAN style communications there is an ever-increasing amount of equipment available for implementing these networks - spread spectrum Ethernet radios, routers that can survive in harsh environments.

Another advantage is the ease of interfacing with office technologies. LAN based Telemetry systems can interface directly into most SCADA software packages

A final advantage is the “distributed” nature of LAN communications. There needs to be no focal point in a network, the Master can be located at any node. RTUs can communicate directly with one another without the need for sending through the Master.

Having said this however, there are some disadvantages that must be considered.

LANs require much more bandwidth that is required by the application, so it will be more difficult to obtain complete coverage – particularly for sewage pump stations and outlying stations. The cost is also high at present. As this application becomes more commonplace the cost is expected to reduce.

The complexity of these systems is also a minus, the technology is not mature and requires lots of routing, setup and other adjustments just to get working.

Last but not least – involvement with LANs means that the user becomes a hostage to the IT section of the utility. The IT culture is not conducive to telemetry and its 24 hour a day, 365 days a year operation. This has been a problem in every installation that we’ve been involved in.

#### 4.2.2 PRIVATE LAN NETWORK

A private LAN network is an expensive undertaking at the moment but costs are coming down. There is a lot of rugged reliable equipment coming on the market which makes implementing this type of networks easier. The constraints are coverage and availability of staff with IT skills as well as radio skills. They are still considerably more expensive than radio networks and if there are coverage problems because of difficult topography or long distances, the cost goes sky high for a single user.

#### 4.2.3 LOW FREQUENCY IP RADIOS

There are now coming on to the market radios with IP protocols and data transmission inbuilt. They also have the virtue of very short startup time, They work on VHF and UHF licensed frequencies and have modulation techniques that are very resistant to noise. Their data rate automatically adjusts to conditions and often goes as low as 4800 bps. These will be the best of two worlds but could be subject to network snarls if not managed properly.

### 4.3 DATA OVER CELLULAR

Data over cellular is gaining popularity. This technology allows the infrastructure of various cell phone networks to be used for telemetry. This saves a lot of capital expenditure but has the limitations of lack of network control and possible coverage issues.

#### 4.3.1 CDMA / GPRS

In New Zealand there are several schemes being used at present. The general technologies are called by their acronyms CDMA and GPRS. GPRS is an addition to GSM (another acronym which has more meaning than Global System for Mobile communication). GPRS technology enables a cell phone connection between IP addresses. The latency is about 2 seconds (as opposed to 20-30 seconds for a dialed connection) and the cost is about 60 cents a megabyte.

GSM is common in Europe, China and parts of USA. GPRS is simply IP over GSM (this means IP calls only). Vodafone is the NZ carrier for GSM.

CDMA is newer technology. It is not as accepted and uses different encoding. It is capable of data calls and IP calls. For a data call one has to “dial the number and wait for ringing” - this typically causes a 20 sec latency. There is a minimum charge of 30 seconds. IP calls have 2 seconds latency.

#### 4.3.2 THIRD GENERATION CELLULAR

Third generation cellular is an IP based cellular network just being launched in New Zealand by Walker Wireless. It is data focused using TCP/IP pipes for data transmission. Instead of a phone number it uses an IP address. An interesting point is that it can use this pipe for digitally encoded voice transmission. There is typically a 25 km radious for each cell, the data rate ranges between 1-11mb. The cost is 5 cents megabyte. It uses packet connection IP.

### 4.4 OPTICAL FIBRE NETWORKS

The use of fibre for communications purposes is burgeoning. Saturn uses fibre networks to bring internet and video signals into households and many large companies have their own fibre networks. Wellington City is trialling CityLink – a fibre network in the CBD. Fibre networks are just getting started so it is difficult to discern a cost structure that will hold steady for the future.

The advantage of fibre is reliability. Unlike copper it doesn’t corrode, short circuit, deteriorate or have other problems associated with copper circuits. It also has the advantage of a high bandwidth.

To run fibre to the RTUs in pump stations can be expensive with trenching and running of fibre cables from each pump station to a multiplexing point (which can be many kilometers away). The cost of fibre itself can also be high.

There is an opportunity to put fibre cables alongside pipes when installing them and saving the cost of trenching etc for cabling alone.

# 5 MAP FOR THE FUTURE

## 5.1 COST EFFECTIVNESS

With a wide choice of communications solutions available, the telemetry user can focus on the most cost effective solution for his needs. In any instance cost or more accurately value for money is the final arbiter of any technology decision. It is not as straightforward as it initially appears. Although there are the usual constraints of measuring initial capital expenditure against cost of operation there are also other less tangible factors in the cost equation. These are: what is the cost of missing communications at a crucial time and what is the cost of losing communications during civil emergencies such as fire or earthquake.

### 5.1.1 CAPITAL COST OF NETWORK

The capital cost of network includes all of the equipment and labour needed to commission it. Private networks typically incur a large capital cost at the outset but this should be offset by low operating costs. When one is evaluating the capital costs of various options the following should be factored in:

1. The maintenance costs of operating a private network. These networks typically are located in large geographical areas and have a life expectancy of 10 to 20 years. Expenditure on durable high quality equipment often represents a costs savings in 20 years of maintenance budgets.

2. There is a benefit in network ownership of the control of availability – especially in emergencies. It is difficult to put a price on this.

3. Obsolescence of technology. Will the technology be available over the expected life of the network?

### 5.1.2 RUNNING COSTS

The running costs of a privately owned network will include capital depreciation, maintenance, channel fees. A shared network has fewer capital costs and can have low running costs if the communications configuration is done properly and charges are for amount of data.

### 5.1.3 COSTS OF UNAVAILABILITY

This is difficult to quantify but should include the possibility of fines for violating a resource consent after an unreported sewage flood or empty reservoir. If a control system is implemented which relies on communications and then fails as a result of a communications failure, there can be serious consequences.

## 5.2 EFFICIENT USE OF BANDWIDTH

Bandwidth is becoming more expensive and less available. Many technologies such as spread spectrum rely on efficient sharing of available frequencies with other users.

### 5.2.1 EFFICIENT POLLING CYCLES

The art of adjusting polling cycles is so the information is updated no more frequently than necessary. The considerations are: how often do I need to update my information at the Master (e.g. hourly flow rates, reservoir levels etc), how long can I tolerate not knowing if the link is operable (lack of response can indicate link failure), and how soon do I need alarms? With alarms it is customary for the RTU to contact the Master without waiting for a poll.

### 5.2.2 TIMESHARE WITH OTHER BANDWIDTH USERS.

Because the bandwidth required by telemetry users is not very great, a number of different users can share the same frequency and available bandwidth. A crude example is one which is practiced in New Plymouth where two users share the same channel. Polling is every 10 minutes and it takes about three minutes to get through the whole cycle. One user polls at, for example, 12:00, 12:10, 12:20, the other at 12:05, 12:15, 12:25. The clocks are synchronized once a day so they don't drift.

## 5.3 EASE OF USE

As data communications becomes more and more a part of everyday life, people will want technologies and systems that are easy to use as opposed to those with spectacular performance specifications. Certainly in telemetry applications data speed is not a factor.

### 5.3.1 EASE OF CONNECTION

People will want to connect their LAN directly into their communications network without the need for interfacing technology. If LAN is not used then the less equipment needed to connect to the Master the better. At the moment this is one of the biggest problems in setting up systems, and effort will be going into technologies and infrastructures to make this aspect of telemetry easier.

### 5.3.2 EASE OF FAULT FINDING

As networks become more complex, fault finding can be a nightmare. A network that comes with tools for accurately diagnosing faults will be highly desirable.

## 5.4 WHAT PEOPLE WILL WANT IN 2020

This is our estimate of what will be the driving factors in the choice of communications systems ten years hence. We feel that establishing communications to the plant will no longer be the technological challenge that it is now. The novelty of having 11 MB data streams will have worn off and the need to run every pump station as a web site with interactive video will have passed.

We believe that the trend will be to select systems that are easy to use, very reliable and have low running costs.

### 5.4.1 TROUBLE FREE

Telemetry and data communications are a means to an end, not an end in themselves. Coverage is the big technical issue rather than bandwidth. A system that goes in and gives little or no trouble will be more attractive than one that has lots of features and associated complexity.

### 5.4.2 EASE OF SETUP AND USE

A system that is easy to implement will be attractive, where the type of equipment doesn't vary (e.g. repeaters are the same as outstation equipment) and there is uniformity in the network configuration. Networks with more than one type of technology such as PSTN mixed with wireless LAN and radio will become increasingly unpopular.

### 5.4.3 LOW RUNNING COSTS

Running costs will be more and more a factor. With different chargeout schemes more attention will be paid to networks that give lowest rates for the rather unique type of application of telemetry. Since systems can be tuned to keep the amount of data transferred fairly low, schemes which charge by the amount of data transferred over a set period of time (daily/monthly) rather than having a call charge factor will be desirable.

## 5.5 HOW TO UPGRADE NOW TO BE READY FOR THE FUTURE

At the moment we are at a crossroads in communications technology for telemetry. We know that TCP/IP will be the major protocol and technique for the future but at the moment it is expensive and difficult to implement. It needs to mature.

So what can we do now if we want to be ready for the developments that we know are coming?

### 5.5.1 AVOID SUNSET TECHNOLOGIES

There are certain technologies which are very likely to be superseded by the newer technologies listed above. Some examples are 2 / 4 wire connection, and trunked radio, which was devised to share spectrum but has been superseded by more efficient technologies.

### 5.5.2 AVOID PROPRIETARY TECHNOLOGIES.

Some communications companies come up with technical innovations that can give significant performance advantage. These are patented and restricted to the innovator companies. The trend is for these to be very successful or widespread but the technology is superseded and it becomes unavailable. (Iridium is an example).

### 5.5.3 TCP/IP CAPABLE RTUS

IP addresses and TCP protocol will be the dominant protocol of the future. At present there are not too many systems using this and most are flaky at the moment. While TCP based systems are too green at the moment they *will* mature and become the "way to go". RTUs should have Tbase 10 connectors which is the de facto standard for LAN/internet connection and TCP/IP capability so that they will be ready for an implementation of a WAN type communications network.

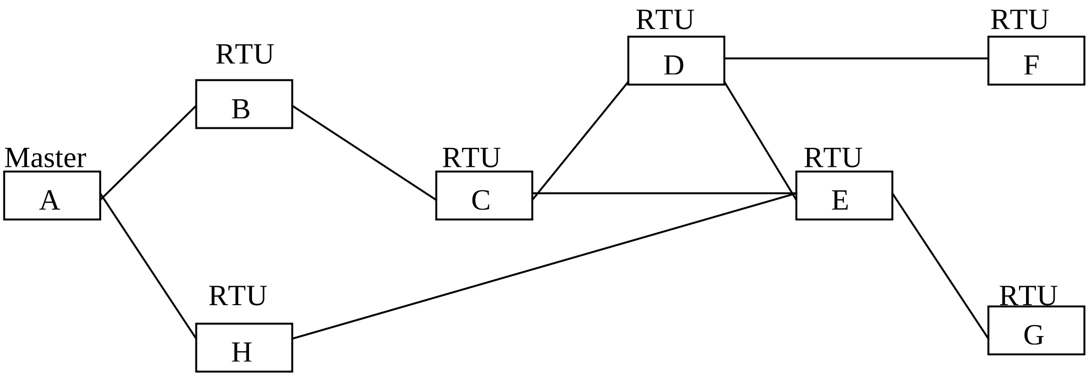



Figure 5: LAN telemetry system

## 5.6 AGAINST THE TREND

As mentioned in 1.3 there is a drive to ever greater bandwidth and higher carrier frequencies. As a result some previously unavailable (and perfectly suitable) lower frequency bands are becoming available again. For a rugged simple system VHF frequencies are completely adequate.

This option is becoming more popular because of its simplicity, coverage and protected frequencies. There are a number of situations where the more modern high frequency and networked configuration just doesn't work or is not cost effective.

Low frequency, moderate speed IP radio technology will bridge the coverage and price gaps but will never be as simple.

# 6 CONCLUSIONS

## 6.1 THE BASIC REQUIREMENTS OF SCADA / TELEMETRY SYSTEMS WILL REMAIN THE SAME

### 6.1.1 ALARMS

With IP protocols, alarm information does not necessarily need to go through a central point such as a Master unit or host computer. It can be routed directly from the source of the alarm to the pager, palm pilot or cell phone carried by the maintenance person who responds to the alarm.

However if the alarm is not communicated then the system will be deemed a failure.

### 6.1.2 DATA

The higher data rates will allow faster updating of the state of reservoirs and pump stations but this is a luxury rather than an essential.

### 6.1.3 CONTROLS

With the high bandwidths it will be possible to implement elegant control systems for water balancing, smoothing flows into treatment plants etc, but these systems are difficult to implement in the best of circumstances. Current communications technologies allow this (as these processes are fairly slow) and they are rarely used.

## 6.2 THERE WILL BE A TREND TO USE COMMUNICATIONS PROVIDERS

Although there are good financial and operational reasons for having a private system there will be less and less of this as the spectrum fills and channel costs rise or channels become unavailable.

### 6.2.1 MORE COMPLEX SYSTEMS REQUIRE ADVANCED SKILLS

The trend towards higher bandwidth has put the ability to install, commission and operate these communications out of the reach of the technical skills of most water/wastewater utility operators.

### 6.2.2 SHARING BANDWIDTH

There is only so much room in the spectrum and it’s filling up fast. The name of the game will be sharing channels more efficiently and this is best done by a communications provider who manages its allocated part of the spectrum.

A communications provider will also have the tools and skills to eliminate any unwanted interference in its allocated spectrum. A private channel is at risk from this.

### 6.2.3 LOWER COST OF OWNERSHIP

Because of the efficiencies of having one service provider manage the infrastructure and frequency and the lack of capital expenditure, the cost of using communications providers will tend to be lower in the future than that of having a private network.

In addition, the running costs of a private network are probably going to rise as the technology becomes more complex and expensive to maintain and the price of spectrum increases.

## 6.3 TCP/IP WILL BE THE DOMINANT PROTOCOL

TCP/IP is a rugged, multi path protocol that is widely implemented across the computer and data communications industry. Its features of multiple possible routes and robust scaleable connection make it ideal for telemetry applications. Rarely do specialist applications and mainstream technologies have such a convergence.

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